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ABSTRACT

The ontogenetic development of human vocal utterances and their role in early interaction processes were studied with a three-month-old baby. Recordings were made of infant vocalizations in the home and the sounds were classified. During a five-minute segment between the mother and infant, the infant produced 59 utterances, 93 percent of which had features typical of flats (i.e., having a fundamental frequency that is smooth, comparably low, approximating pure harmonic tones, and having a similarity to vowels). A computer program was developed to plot the fundamental frequency, intensity, and time pattern of the vocal utterances of both partners. The amount of turn-taking suggests that the infant not only produced a series of vocalizations but actually engaged in a kind of conversation. Those phrases that the baby responded to had a common feature: they exhibited a very similar pitch contour. Fifteen out of a total of 18 utterances with a rising contour were responded to by the infant during a segment. There was a surprising conformity between the utterances within each episode: in some cases the mother imitated the baby and in others the baby was able to copy the pitch contour of the mother's voice within certain limits. Reciprocity, imitation, and the use of bell-contours appeared to be important to the success of the exchange. The mother intended to talk with the baby and used infant-oriented speech, which the baby responded to within a few seconds. It is suggested that the rising contour vocalizations were used by the mother as turn-markers, strongly compelling the infant to respond. (SW)

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VOCAL COMMUNICATION WITH A THREE MONTH OLD BABY

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The goal of our present work is to describe the ontogenetic development of human vocal utterances and their role in early interaction processes. Long before infants are capable of performing the complex articulatory movements necessary to produce phonemes or even words, they are able to express their internal state, their feelings, and their wishes and dislikes vocally. Their means of vocal expression are the paralinguistic features of the voice. It is presumed that musical elements that is prosodic or nonsegmental parameters (Crystal 1973) are essential mediators in the development of communicative skills (Papousek and Papousek 1981). In a comprehensive study Rachel Stark and her co-workers have explored relations between infant behavioural parameters and vocalizations (Stark et al 1978, Stark 1978). They found that in spite of a primary reliance upon contextual cues and commentarys, listeners classified the vocalizations according to auditory features of the vocalizations themselves. These features differ from those of phonemes, and for this reason the International Phonetic Alphabet is not sufficient for an adequate description of early infant vocalizations. Thus, we have begun to elaborate a classification system for infant vocalizations.

METHOD:

In a longitudinal study with six babies and their families we are developing a system for classifying infant vocalizations based on acoustical, prosodic and musical as well as on interactional features. Once a month we made two-hour home recordings in each family between birth and the end of the first year. The auditory and sonagraphic analysis of the first recordings of the six infants showed that newborns already have a diverse repertoire of vocal capabilities.

VOWEL-LIKE SOUNDS:

In general vocal utterances of newborns differ from those of adult speakers not only because of the infants' inability to control articulatory movements, but also because of the phonatoric properties of infant vocal productions. For example, typical phenomena of infant vocal production are waves or oscillations of the fundamental frequency. Only a small number of utterances deviate from this pattern. Since we started this work without a nomenclature, we have tentatively called the sounds of this type " Flats ". This name reflects an essential feature of these vocalizations which clearly distinguishes them from those of all the other groups. The fundamental frequency of these few exceptions is smooth. It may rise or fall, but it is always free of any oscillations. These few utterances have some additional characteristics: they have a comparably low fundamental frequency; the energy of the frequency spectrum is concentrated on the lower part of the sonagram that reaches an upper level of 4000 Hertz; and they approximate pure harmonic

tones. Thus they not only appear rather similar to vowels in the sonagrams but also sound vowel-like.

An important question arises as to when the infants produce this form of utterance. Since our data stem from naturalistic observations it was impossible to anticipate the occurance of situations which would feature the production of vowel-like sounds. By chance one of our mothers made her three-month old baby produce a series of these sounds as she changed his diaper. The baby lay on the table. The mother bent down to her boy and brought her face very close to the infant's . She stopped all movement except some typical head rises concomitant with her speech. The infant looked straight into his mother's face. He strained to maintain contact.

RESULTS:

During a five minute segment of this interaction episode the infant produced 59 utterances. Ninety-three percent of them have features that are typical of Flats. Among thousands of vocalizations of the newborn-period we have found only some isolated Flats.

Figure 1

With this 3-month-old baby we found more than 50 within 5 minutes. But we should be careful in relating this to the dialogue situation because we have no data about the overall distribution of these sounds. Since infants exhibit a lot of sound production when alone (Laufer and Horii 1977, Delack and Fowlow 1978), vowel-like sounds often appear in monologues (Papousek and Papousek 1981).

It is still premature to offer interpretations about the meaning of the Flats. It has been suggested that they are concomitants of cognitive processes (Papousek 1961), and that they are dependent on behavioural states of the infant (Papousek 1977). Placid cooing has been interpreted as expressing comfort . Unlike all the other sounds of the newborn period the frequency range of these vocalizations is very narrow during the first weeks of life. But within 2 months both their number and their fundamental frequency ranges increase enormously and they appear in groups that are well-known to everybody as cooing. Thus, the development of the Flats parallels that of the vowel-like sounds that Papousek and Papousek (1981) describe in a case-study. The Papouseks assume that this development reflects the increasing 'control of respiration for the sake of vocalization' (Papousek and Papousek 1981). Thus the alterations of the vowel-like Flats would be direct acoustical parameters of increasing motor control of the vocal apparatus.

To analyze the data we have developed a computer program to plot the fundamental frequency (f), the intensity and the time pattern of the vocal utterances of both partners. For the present analysis we used a time interval of 40 seconds . Table 1 shows the number of utterances of the infant and his mother.

Table 1

Number of utterances of 8 succeeding intervals of each 40 sec.

Mother :	16	11	10	12	11	13	11	10
Infant :	5	14	12	9	6	8	5	-
Turn-tks.:	4	9	9	3	5	5	5	
M. Non-Rising:		12	8	10	11	8	9	8 10
Responses:	1	8	9	4	2	1	(5)	
M. Rising:	4	3	-	1	3	4	3	-
Responses:	4	3	-	1	2	4	-	-

During the first 40 seconds the mother produced 16 utterances and the infant only five. During the next two intervals the baby vocalized frequently. He produced even more utterances than the mother. In the succeeding intervals the number of infant vocalizations decreased constantly and finally dropped to zero for several minutes. The mother emitted a relatively constant rate of utterances throughout the dialogue. The number of turn-takings during this episode suggests that the infant not only produced a series of vocalizations but actually engaged in a kind of conversation.

THE RISING CONTOUR:

We may understand some of the rules regulating the exchange when we examine the fundamental frequency of their vocal utterances. In Figure 2 the first fourteen vocalizations of the mother are shown. The mother initiated the dialogue. Only a few of her phrases and invitations were responded to by the baby. But those phrases that were responded to do have a common feature: They exhibited a very similiar pitch contour. The fundamental frequency rose about 150 to 200 Hertz within 0.2 seconds. Among the first sixteen utterances of the mother each one that had such a final pitch rise was responded to, wheras only one differently shaped pitch contour was followed by a vocal reaction from the infant. The fundamental frequency contour of this one exception had a final rise of 120 Hertz within 0.3 seconds.

Figure 2
THE FIRST 14 UTTERANCES

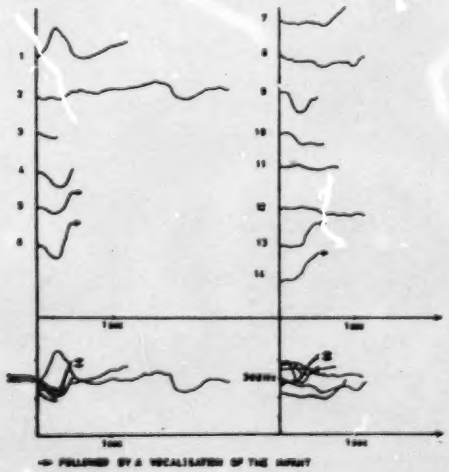


Figure 3
RISING CONTOUR

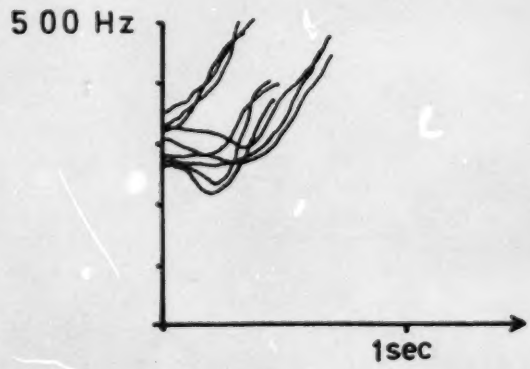


Figure 3 shows several examples of the rising pitch contour and the absolute position of their fundamental frequency. 15 out of a total of 18 utterances with a rising contour were responded to by the infant during this dialogue. Only the last three of them failed to elicit a response from the baby. The distribution of the utterances with a rising contour mirrors the vocal responsiveness of the infant. In the beginning the vocal responsiveness was low and the mother used the rising contour several times. When the responsiveness of the baby was high the rate of the rising contour decreased, yet it increased again when the responsiveness phased out. However, the final rise of the pitch is not the only strategy the mother used to engage her baby. Often she began with a simple shaped utterance, the structure of which became amplified when not immediately successful. This took the form of a rise in the pitch contour, an amplification of the time pattern, or a syntactical expansion.

THE BELL-CONTOUR SEGMENTS

With regard to the mean fundamental frequency, the mother adjusted her own voice to the infant's. The magnitude of the shift from her every-day voice to her baby-talk voice was around 150 Hertz. The prevailing pitch contour in her talk was the bell-contour. It is not possible to decide whether this feature was also the result of an adaptation of her talk to the infant's or whether it arose from the specific form of interaction. Both the mother and the infant produced this pitch pattern. The production of this pattern was not independant of the partner's preceeding vocalization. During the dialogue there were several chunks of bell-contour-vocalizations separated from one another by utterances with undifferentiated patterns. In Fig. 4 we have plotted several episodes with bell-contours. Some of these episodes were initiated by the mother and some by the infant. There is a surprising conformity between the utterances within each episode. This means that in some cases the mother imitated the baby and in others the baby was able to copy the pitch contour of his mother's voice within certain limits. These examples demonstrate that it is not the same contour in all the episodes that is imitated, even though they all have a more or less bell-like configuration. One partner always generated a model, which the other one repeated. Then the initiator completed the theme with a final repetition of his own model. When the first attempt to repeat the melody was not good enough, a second attempt was made (Fig. 4, examples 4, 5 and 6). In this dialogue there was not only reciprocity of single vocalizations but there was also turn-taking with regard to generating the themes . Reciprocity, imitation and the use of bell-contours seem to be central elements contributing to the success of this exchange. At some point in the discourse the game was over. It was not possible to determine whether the infant was exhausted or whether the mother failed to follow the rules of the game. The frequency of responses of the baby decreased and the adaptability of the mother diminished as well. Figure 5 illustrates the last six utterances of the baby together with in each instance the preceeding and the succeeding utterance of the mother. Neither the baby nor the mother imitated the partner during the time interval presented here.

Figure 4

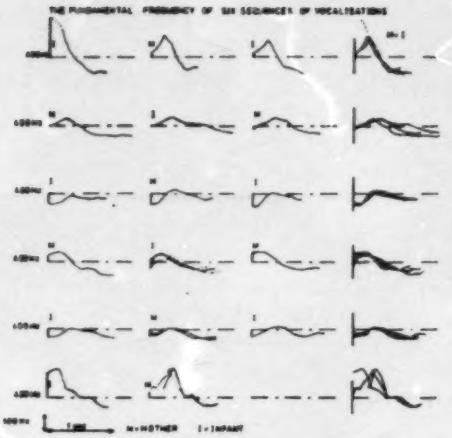
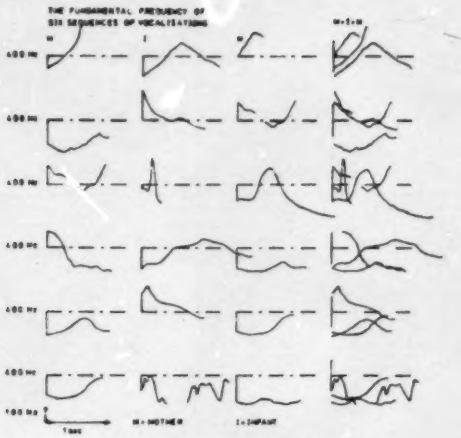


Figure 5



DISCUSSION:

The mother wanted to talk with her infant. Her commentary at the end of the talk revealed that she was successful. In the mother's own words: "He never has spoken so much to me before." It is known from crosscultural observations that mothers are able to talk with their three-month-old infants . Unconsciously mothers exhibit alterations in their behaviour that help the infants to display certain action patterns. We know from our own observations that mothers intuitively change their motor behaviour and their position when they try to initiate a conversation. They stop their gross movements and bring their face to within a short distance of the infant's. The function of this shortening of distance during interaction is still undetermined though it can be observed reliably (Schoetzau and Papousek 1979).

When the mother bent down to her baby she began to talk in a typical mode. The alteration in parental speech is one of the most prominent features of interaction between parents and children (Ferguson 1964, Snow & Ferguson 1977,). It is supposed that this alteration is an adaptation to the infants' and toddlers' cognitive abilities and that it supports the acquisition of language structure (Snow & Ferguson 1977). The automatic modifications of the voice are difficult to reproduce without the actual presence of an infant (Fernald 1976), or if the child provides no feedback (Snow 1972), and they appear to be adjusted to developing aspects of young children themselves. It is plausible to hypothesize that the modifications of infant- or child-directed speech are influenced by the children. However, despite numerous studies, the evidence does not yet indicate what specific child variables shape child-directed talk (Van Kleek 1979). In particular, the features of baby-talk, that is infant-directed speech, cannot be explained by the often discussed comprehension model (Van Kleek 1979).

Mothers are able to tune their behavior exactly to the behavioural state of infants (Brazelton et al 1974, Papousek & Papousek 1977) ostensibly because the behavioural state is expressed via multiple channels. One of the strongest elicitors of maternal reactions is the infant's voice (Snow 1977).

Mothers respond to almost 100% of all infant vocalizations (Snow 1977), and more or less they meet the needs that are expressed vocally, as Bell and Ainsworth demonstrated in a longitudinal study (1972). The intuitive reaction of the mother in the dyad described here is exclusively a vocal one. And her conscious interpretation of the infant's needs tends in exactly the same direction. Since the boy showed no signs of distress or anger the mother obviously met his needs. Apparently the baby's vocalizations carried the necessary information to communicate his needs. We believe that the type of vocalization he used was the dominant feature. Notwithstanding, the question whether these vocalizations were expressions of a primary communicative need or incidental byproducts of a behavioural state remains open. Important is the fact that the mother interpreted them as a means of communication and that she reacted in a way that was satisfying for the infant.

Many of her utterances showed a rising-falling contour or so-called bell contour (Stern & Wassermann 1979). The intonational contours of the mother may reflect an adaptation to the infant's pitch contours. According to Delack and Fowlow (1978), the proportion of rising-falling contours increases during the first year while the proportions of simple falling or simple rising contours decrease. Thereafter the similiarity between the vocalizations of the two partners of our analysis might be due to maternal imitation. Generally, mothers tend to repeat their infant's expressions, moods and vocalizations (Papousek & Papousek 1977, Pawlby 1977). Imitation perhaps plays a crucial role in the development of cognitive abilities and ego-development (Uzgiris 1981). It creates situations which allow the infants to perceive contingent reactions of their behaviour. And it allows them to compare both imitated and imitating activities.

In the course of this conversation there is, however, clear evidence that the infant also imitates the mother. Matching of facial expressions, finger movements, gestural movements and vocalizations already occurs in the first weeks of life (Meltzoff & Moore 1977, Fridman 1974). Though other studies have challenged the replicability of these findings or their interpretation as imitations (Uzgiris 1981, Papousek 1981), there is undoubtedly a capacity to imitate that increases with age. Vocal imitation during the first few months is limited to single sounds (Fridman 1973, Pawlby 1977) and to the copying of pitch contours (Fridman 1973, Lieberman 1975). Sweeny (1978) reported of a girl that at the age of only six weeks was able to imitate the song of a bird.

The important role of imitation for the development of speech is obvious. However, in stressing the cognitive nature of imitation and in stressing its importance for cognitive development, little attention has been paid to its interpersonal aspect. Imitation is a fundamental experience not only for the infants but also for the parents. Ignoring the general rate of occurrence of specific infant acts, mothers have the impression that infants imitate them, due to a tendency to focus on those instances when a congruence is obtained (Lewis 1979). In fact, both the mother and her boy imitated each other during the conversation. This bidirectionality, along with the periodical turn-taking in initiating a new melody, suggests that in this

situation imitation is only one feature of a social game which has evolved in dyadic interaction. The attainment of an imitative response provides the feeling of mutuality and of being understood (Uzgiris 1981). The exchange of vocalizations thus gains a fundamental meaning for the partners.

On the other hand it has often been conjectured that various intonational shapes may have an internal, innate meaning, specific communicative functions (Ferguson 1964, Lieberman 1975, Stern & Wassermann 1979, Ryan 1978). Within linguistic theory meaning is tightly coupled with intention, but that does not circumvent the problem of how to define meaning. In the dialogue reported here, the mother intended to talk with the baby. She talked to him using infant-oriented speech and within a few seconds the baby answered. The use of higher pitch and exaggerated intonation have been shown to elicit attention in babies (Sachs 1977). Rising intonation is said to have a stimulating influence on the child, to be a basic means for elevating the infant's alertness (Papousek & Papousek 1977) and to regain eye-contact (Stern & Wassermann 1979). Yet, as the little boy did not lose eye-contact, in this case it was not a question of regaining it. Rather, the primary goal of the mother was to get the child to take his turns. It was she who imposed on the interaction the rules of the game, the rules of conversation. The rising contour vocalizations were used by her as turn-markers, strongly compelling the infant to respond.

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(1) The Fundamental frequency was determined by a program developed by Dr. Th. Simon, Institut fuer Phonetik und sprachliche Kommunikation, Muenchen.

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